DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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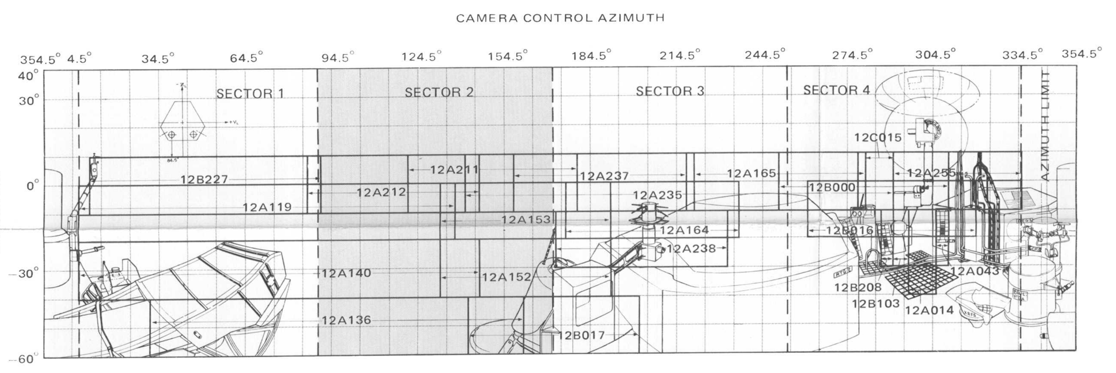
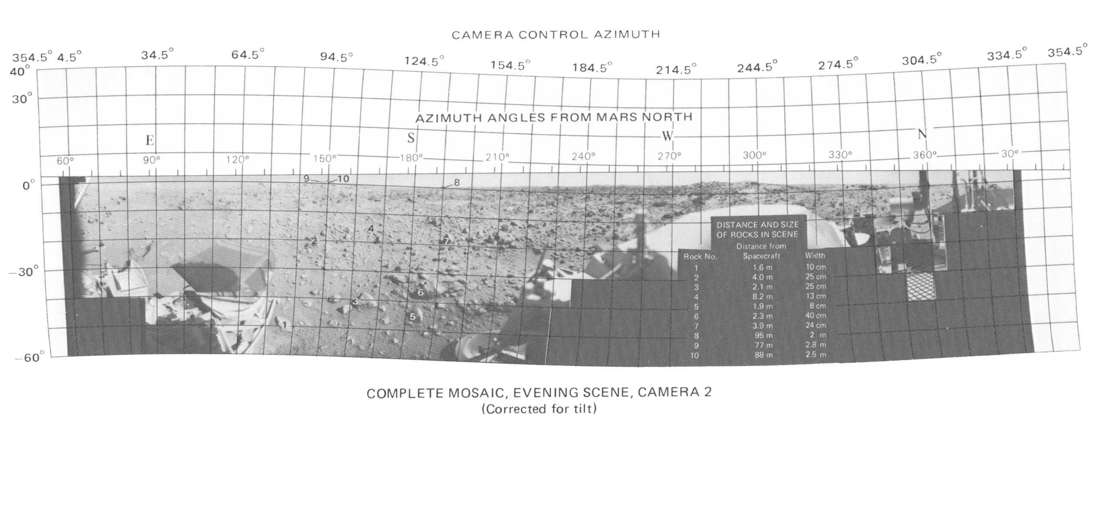
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
VIKING LANDER MOSAIC SERIES
VIKING LANDER 1, CAMERA 2, SECTOR 2
I-1367 (SHEET 3 OF 5)

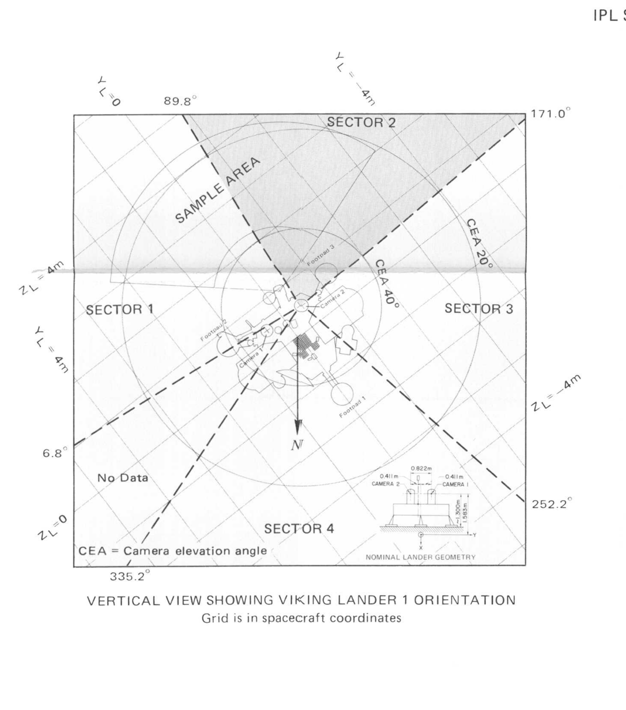
Interior—Geological Survey, Reston, Va.—1982—G81144



OUTLINE OF CAMERA 2 VIEW SHOWING CAMERA EVENTS USED IN MOSAIC



COMPLETE MOSAIC, EVENING SCENE, CAMERA 2
(Corrected for tilt)



VERTICAL VIEW SHOWING VIKING LANDER 1 ORIENTATION
Grid is in spacecraft coordinates

DESCRIPTION OF SCENE

This southward view of the terrain directly in front of the lander shows a surface strewn with rocks in the centimeter-to meter-size range; several areas interpreted as bedrock are also present (line 275, sample 2700). Much of the near field between the large blocks is blanketed by very fine grained (approximately 100 μm) material, which has been sculptured by the martian winds into tails behind rocks (line 900, sample 2700). Light and dark drifts of this material can be seen in the upper left of the mosaic; these deposits are about 15 m from the spacecraft. Large blocks on the near horizon in the upper left of the mosaic are about 80 m from the spacecraft and lie on the rim of a small (200-m diameter) degraded crater; the largest block is about 3 m across. The far horizon at the upper right is probably a ridge beyond the 3-km nominal horizon.

The bottom edge of the mosaic is about 1.7 m from the camera. Footpad 3 of the spacecraft can be seen in the lower right. Immediately above the footpad is a disturbed area or small crater made by the impact of a hollow metal canister that covered the surface sampler until after the landing on Mars. The canister was ejected from the sampler arm upon command from Earth. The windswept or scoured appearance of the surface at the lower left was caused by exhaust from the rocket engines during landing of the spacecraft. Small rocks and fragments blown out by the engine exhaust made little pits and tracks in the fine-grained material as the rocks rolled along the surface (line 850, sample 4000).

THE VIKING MISSION

Two Viking spacecraft, each consisting of an orbiter and lander, were launched from Kennedy Space Center on August 20 and September 9, 1975. The Viking 1 spacecraft arrived at Mars on June 19, 1976, and was placed in a highly elliptic orbit around the planet at a periapsis altitude of nearly 1500 km. The orbiter cameras were used in conjunction with other instrumental methods to find a suitable landing site for the lander. After about 30 days in orbit, the lander was separated from the orbiter, and on July 20, 1976, Viking Lander 1 touched down on the surface of Mars at lat 22.483° N.* and long 47.968° W. (Morris and Jones, 1980) on the west edge of a large basin called Chryse Planitia. It landed in a stable position at a 3° tilt downward in the direction 284.9° clockwise from north.

The side of the lander on which the two cameras are mounted faces southeast. When the cameras are pointed in a direction normal to the front of the lander, the viewing direction is 141.6° clockwise from north along the horizon. The first picture from the surface of Mars, of an area near the lander's footpad 3, was taken immediately after landing by camera 2. During the ensuing 43 days, the cameras responded to all commands and successfully carried out their assigned mission. On September 2, the activities of Lander 1 were reduced to accommodate the planned receipt of data from Viking Lander 2.

On September 3, 1976, Viking Lander 2 successfully landed on Utopia Planitia of Mars (47.966° N., 225.736° W.), more than 6500 km northeast of Lander 1 (Mayo and others, 1977; Davies and others, 1978). Lander 2 faces approximately north and tilts 8.2° downward in the direction of 277.4° clockwise from north. The viewing direction of its cameras when pointed in a direction normal to the front of the lander is 29.0° clockwise from north along the horizon. The cameras on Viking Lander 2 operated successfully for 61 days until the primary mission of both landers was completed on November 15, 1976, at solar conjunction.

During the primary mission, 454 pictures of the martian surface were processed from Viking Lander 1 data and 582 pictures from Viking Lander 2 data. The extended mission of Viking began December 15, after solar conjunction, and ended in June 1978. During this period, an additional 1636 pictures were obtained from Lander 1 data and 1311 pictures from Lander 2 data. A comprehensive description of the Viking primary mission and the results of eight scientific experiments on board the landers were published in the Journal of Geophysical Research (v. 82, no. 28, Sept. 30, 1977; see References).

*Latitudes are areographic (see de Vaucouleurs and others, 1973).

VIKING LANDER MOSAICS

The Viking Lander cameras acquired many high-resolution pictures of the Chryse Planitia and Utopia Planitia landing sites. Each picture is the product of computer processing on Earth of digital-image data transmitted from Mars as a result of "camera events" carried out by one of the lander camera systems. Further computer processing of data from a selected number of these events yielded a total of 10 mosaics. Two pairs of mosaics from Lander 1 data (one mosaic from each camera) consisted of one pair made from data taken in the morning (0700-0800 hours) and one pair made with data acquired in midafternoon (1400-1530 hours). Similarly, three pairs of mosaics for the Lander 2 site consisted of one pair between 0700 and 0800 hours, one pair at noon, and one pair between 1700 and 1800 hours.

Procedures used for processing the Viking Lander camera data were described by Levinthal and others, (1977). The individual camera events used in each mosaic are identified in the outline of the accompanying camera view. Detailed descriptions and reproductions of these camera events were given by Tucker (1978). Copies of the Viking Lander pictures can be obtained from the National Space Science Data Center, Goddard Space Flight Center, Greenbelt, MD., 20771.

The Lander camera system (Huck and others, 1975a) has selectable focus settings for a depth of field from 1.2 m to infinity in the high-resolution (0.04° instantaneous field of view) mode. The survey (low-resolution) mode has an instantaneous field of view of 0.12°; this mode was used in the mosaics only where no high-resolution data were acquired.

Each complete mosaic extends 342.5° in azimuth, from approximately 5° above the horizon to 60° below. A complete mosaic incorporates approximately 15 million picture elements (pixels). In order to manage the processing of such large data bases, each mosaic was compiled from four individual azimuthal sectors.

Most of the data used in the mosaics were selected from the primary mission. In some cases, extended-mission data were included where primary-mission coverage was absent or where the surface was obscured by the sampler arm. Further selection was made on the basis of optimum focus.

The image data were photometrically corrected (Huck and others, 1975b; Patterson and others, 1977; Wolfe and others, 1977) for differences caused by variations in exposure and for solar-lighting differences caused by minor time-of-day variations in the pictures of the set. The geometry was then transformed to a local Mars horizon and corrected for geometric camera errors (Patterson and others, 1977; Wolfe, 1979). The corrected pixels composing a sector were then combined by the computer into a single image, and an optimum contrast correction was applied.

The mosaics are composites of the best pixels of all the Lander pictures used for each sector. In the computer mosaicking process, the image data derived from the camera events for each sector were assigned priorities on the basis of quality or detail. These data were examined by the computer in sequence according to the priorities, and the best pixels of each data set were used for the mosaic.

The computer formatting of the Viking Lander mosaics was done at the Image Processing Laboratories of the Jet Propulsion Laboratory of the California Institute of Technology, Pasadena, Calif., under the general supervision of Elliott C. Levinthal of the Department of Genetics, Stanford University, who represented the Viking Lander Imaging Team. A detailed description of the multiple steps involved in the construction of the Viking Lander mosaics and an acknowledgment of the many people who assisted in the project were given by Levinthal (1980).

GEOMETRY OF THE MOSAICS

The cameras on the Viking Lander acquire data by sampling in equal increments of elevation and azimuth angle. In the accompanying mosaic, 8 mm subtends a 1° horizontal or vertical angle, regardless of the place of measurement within the panorama. If the martian surface were flat, one pixel (0.04° on the surface would be 1 mm wide at -60° camera elevation and 2 m wide at the horizon 3 km away. Characteristically for this type of imaging system, most straight lines in the scene appear curved in the reconstruction. This representation of the picture data differs from that of a conventional camera having "point perspective" picture geometry, in which rays are projected from object space, through the perspective point in the camera lens, to an image plane in the camera.

The geometry of the lander pictures is complicated by additional factors. Because both landers are tilted with respect to the horizon, on the uncorrected pictures the horizon resembles a sine curve. Computer rectification of the pictures results in a straight horizon along which vertical angles can be measured with respect to the local gravity vector, and horizontal angles can be measured from martian north. These angles are not related in any simple way to the azimuth and elevation angles given in "camera coordinates" for the unrectified pictures.

There are other geometric distortions due to the camera: optic path distortion that affects a light ray after it passes the camera windows; and camera-system distortions, or "bolt-down" errors, that are caused by the way the cameras are mounted on the lander. The geometric transformation used in creating the mosaics took into account the optic path distortion but not the "bolt-down" errors. However, along the horizon, the error in azimuth angle is equal to the rotational "bolt-down" error for each camera to an accuracy of less than 1 pixel. The scale "azimuth angles from Mars north" has been adjusted to take into account this correction.

The residual azimuth angle errors are less than 1 pixel along the horizon and become larger with steeper elevation angles and large lander tilts. For the worst case, Lander 2, camera 1, this error is a maximum of 5.7 ± 1 pixels at -60° elevation. The somewhat sinusoidal azimuth-dependent residual elevation error is a maximum of 3 ± 1 pixels for Lander 2, camera 1, and approximately 1 pixel for the other cameras.

REFERENCES

Davies, M. E., Katayama, F. Y., and Roth, J. A., 1978, Control net of Mars: February 1978: Rand Corp. R2309-NASA, 91 p.

Huck, F. O., McCall, H. F., Patterson, W. R., and Taylor, G. R., 1975a, The Viking Mars Lander camera: Space Science Instruments, v. 1, no. 2, p. 189-241.

Huck, F. O., Burcher, E. E., Taylor, E. J., and Wall, S. D., 1975b, Radiometric performance of the Viking Mars Lander cameras: U.S. National Aeronautics and Space Administration Technical Memorandum TMX-72692.

Levinthal, E. C., and Jones, K. L., 1980, The mosaics of Mars as seen by the Viking Lander cameras, NASA Contractors Report 3326.

Levinthal, E. C., Green, William, Jones, K. L., and Tucker, Robert, 1977, Processing the Viking Lander camera data: Journal of Geophysical Research, v. 82, no. 28, p. 4412-4420.

Mayo, A. P., Blackshear, W. T., Tolson, R. H., Michael, W. H., Jr., Kelly, G. M., Brenkle, J. P., and Komarek, T. A., 1977, Lander locations, Mars physical ephemeris, and solar system parameters: Determination from Viking Lander tracking data. Journal of Geophysical Research, v. 82, no. 28, p. 4297-4303.

Morris, E. C., and Jones, K. L., 1980, Viking 1 Lander on the surface of Mars: Revised location: Icarus, v. 44, no. 1, p. 217-222.

Patterson, W. R., III, Huck, F. O., Wall, S. D., and Wolfe, M. R., 1977, Calibration and performance of the Viking Lander cameras: Journal of Geophysical Research, v. 82, no. 28, p. 3491-4400.

Tucker, R. B., 1978, Viking Lander imaging investigation—picture catalog of primary mission experiment data record: National Aeronautics and Space Administration Reference Publication 1007, 558 p.

de Vaucouleurs, G. D., Davies, M. E., and Sturms, F. M., Jr., 1973, The Mariner 9 areographic coordinate system: Journal of Geophysical Research, v. 78, no. 20, p. 4395-4404.

Wolfe, M. R., 1979, Viking Lander camera geometric calibration report: California Institute of Technology, Jet Propulsion Laboratory, (in press).

Wolfe, M. R., Atwood, D. L., and Morrill, M. E., 1977, Viking Lander camera radiometry calibration report: California Institute of Technology, Jet Propulsion Laboratory Publication 77-62, v. 1, 90 p.

VIKING LANDER 1 RECTIFIED PHOTOMOSAIC
EVENING SCENE - CAMERA 2 - SECTOR 2
1982